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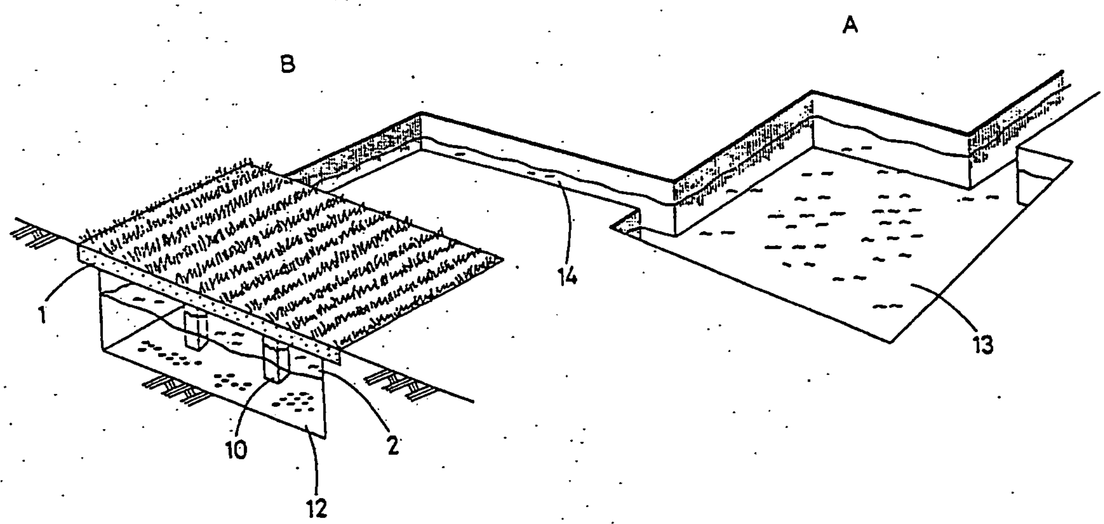
A1E
A1B
Selected US specifications from IPC sub-class
A01G

(54) Method and apparatus for watering plants

(57) Plants are nourished by water which has been warmed in a pool (13), preferably by solar radiation during the daytime, and then evaporated from a reservoir (2) at nighttime and condensed on, and absorbed into, an overlying layer of soil (1).

FIG. 1.



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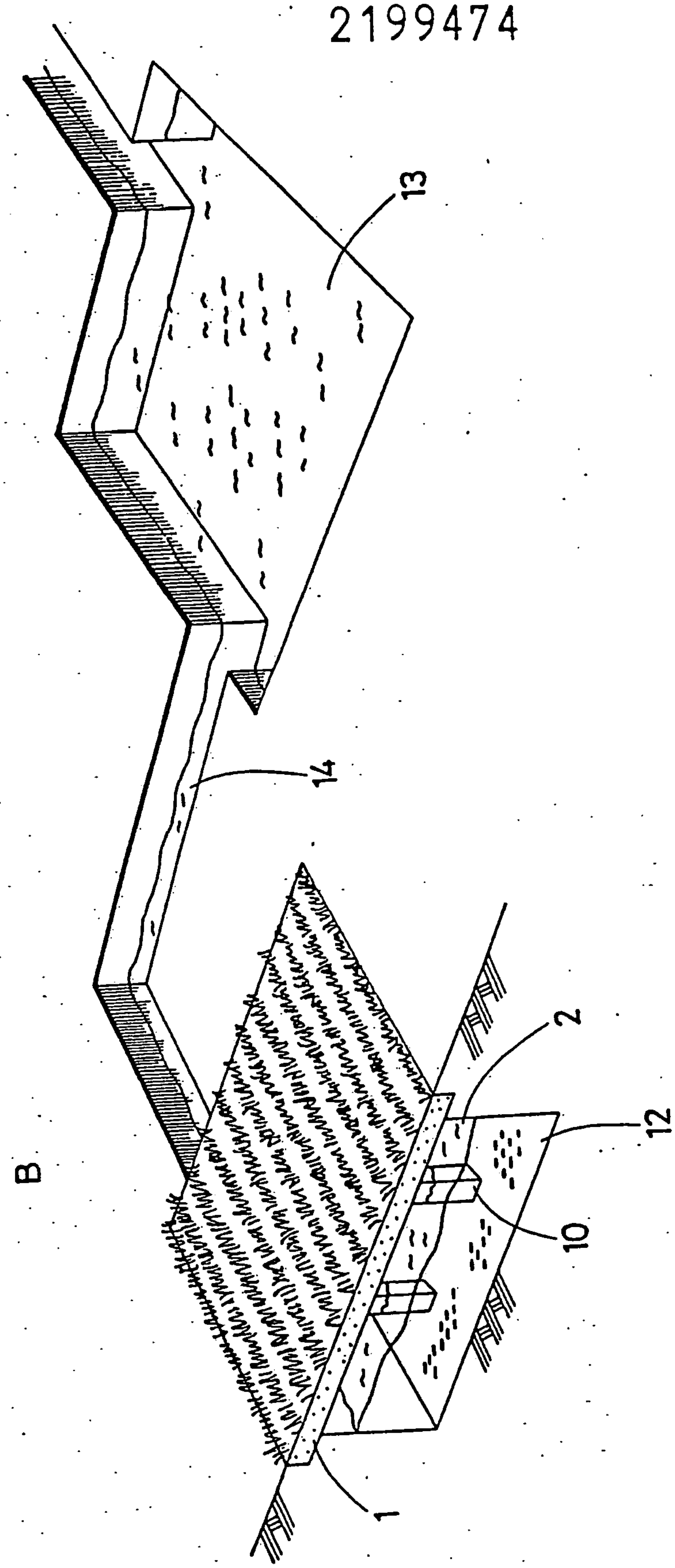

FIG. 1.

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FIG. 2.

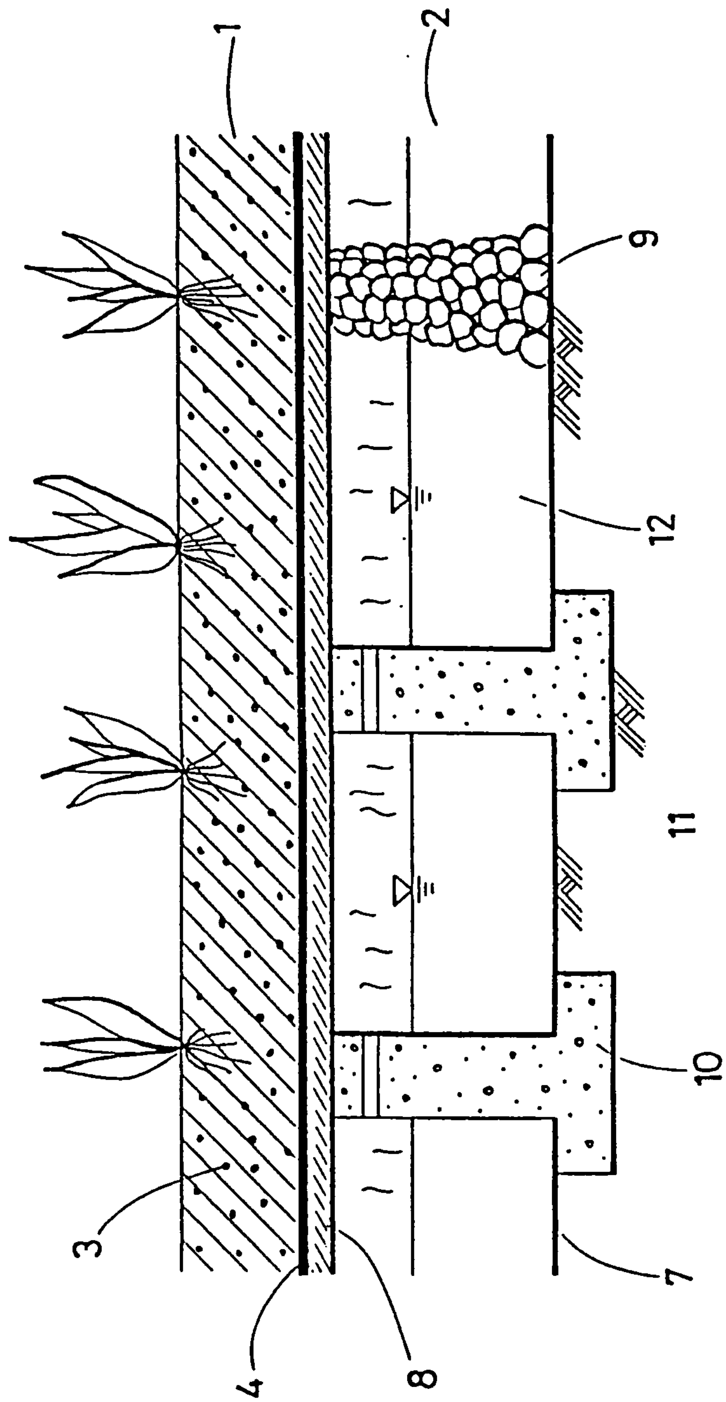

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FIG. 3.

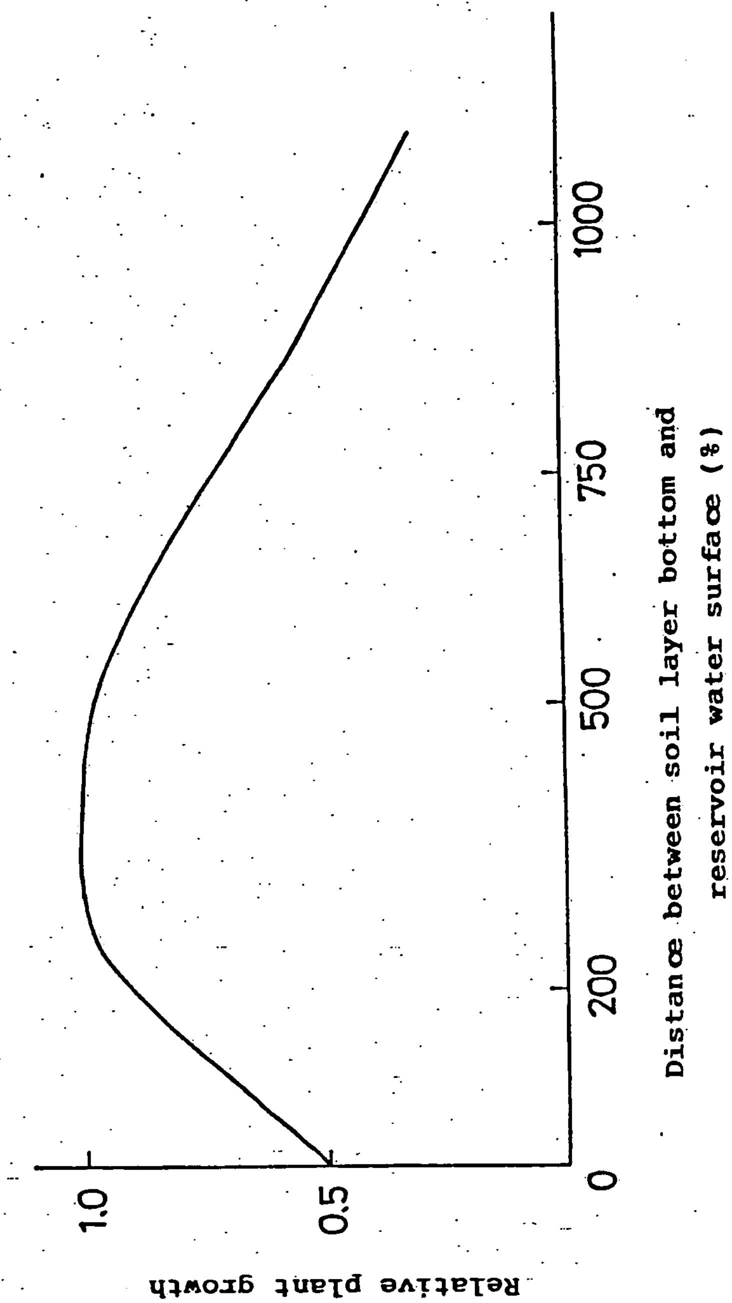

FIG. 4.

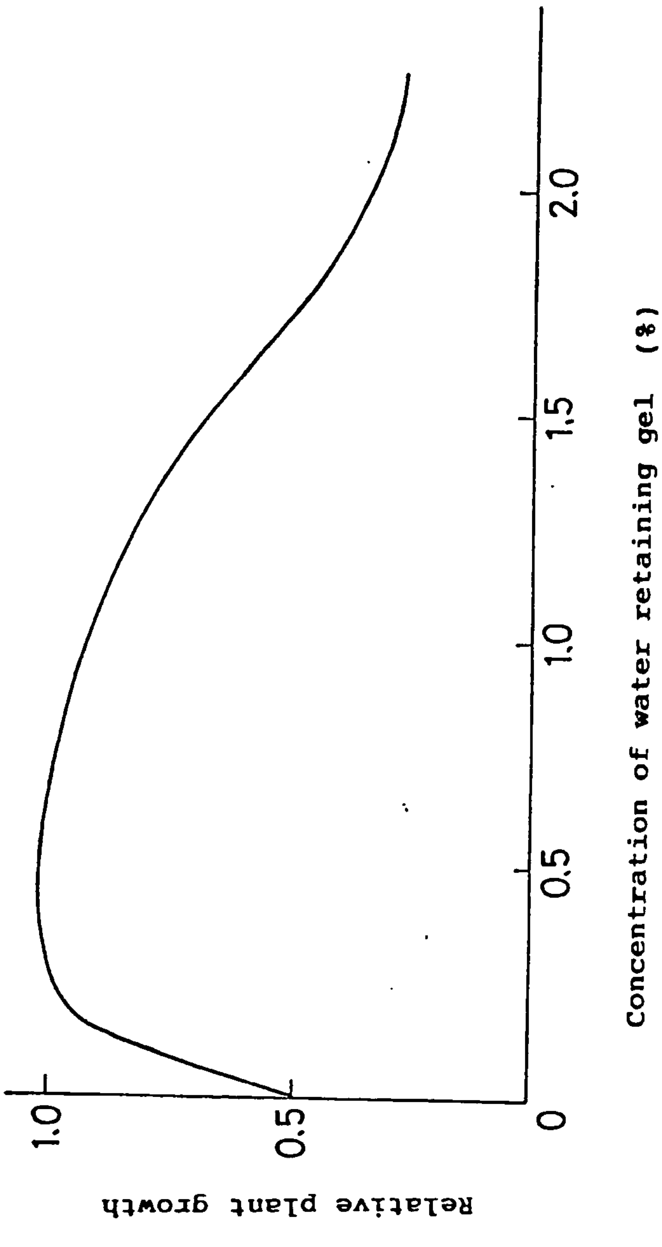
Relative plant growth
1.0
0.5
0
0.5
1.0
1.5
2.0
Concentration of water retaining gel (%)

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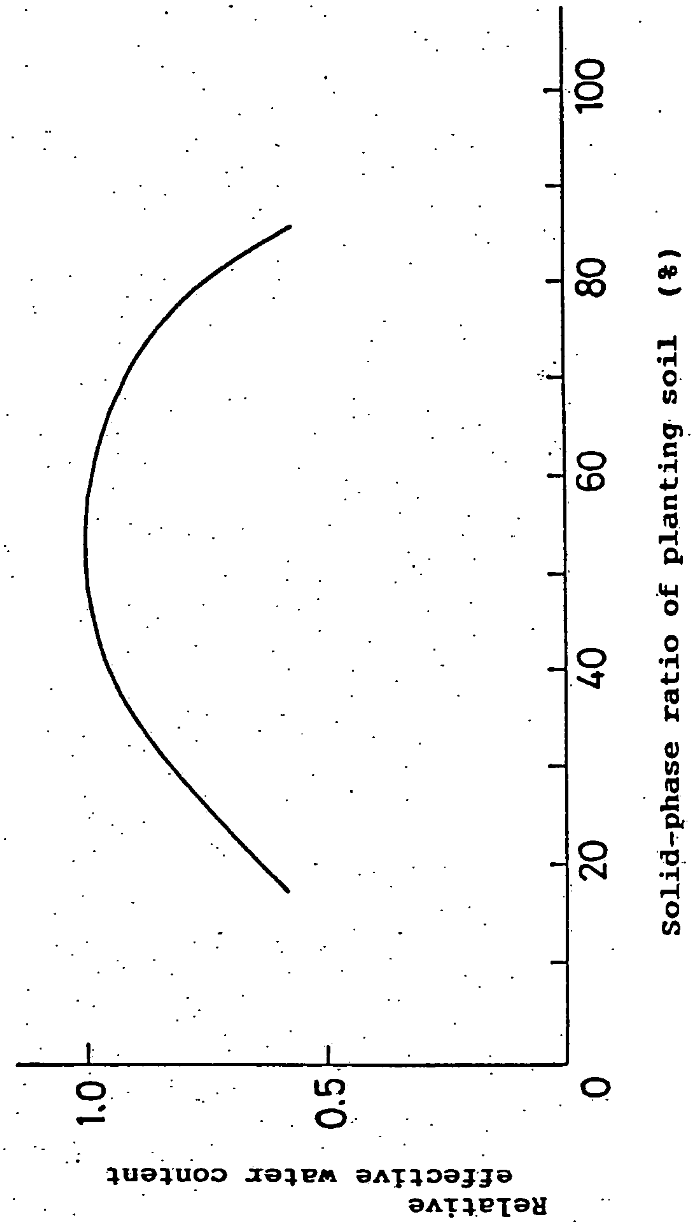
FIG. 5.



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DESCRIPTION

METHOD AND APPARATUS FOR WATERING PLANTS

This invention concerns a method for supplying water to soil or other growing medium for plants, by employing dew condensation, particularly for use in arid zones where the daytime-nighttime temperature difference is up to 20° C or more.

Conventionally, sprinkling or dripping water frequently and abundantly on the surface, or into the subsoil, of land, has been used for agricultural irrigation in arid zones where the amount of rainfall is small and, contrarily, water evaporation is great. To prevent water evaporation, a covering of bark-mulch, or vinyl houses, or various water retaining agents are used. However, these conventional methods have problems. Thus salt components are salted out from surrounding soil, both in the case of surface and underground irrigation and the resultant salted-out components accumulate at the land surface. To solve this problem, local irrigation of soil in a plant root area with the necessary amount of water or flushing of the soil with low salt, or fresh, water is required. Moreover, the effectiveness of conventional irrigating methods is extremely low because a large amount of water evaporates from the surface of the land, particularly in arid zones, such as desert, owing to the high temperature on the land surface through solar radiation in the daytime, and, owing to dissipation of absorbed daytime heat, in the nighttime as well. Accordingly, an abundance of water is generally required so as to maintain a sufficient water supply for plants. Consequently, in order to satisfy the necessity for an abundance of fresh water supply, systems such as salt-to-fresh

water distillation have been employed. However, the cost of building plant, the high energy consumption, and the introduction of technology and the necessary technical training are a big burden to countries, especially to developing countries that generally have large arid zones.

According to the invention, in a method of watering plants, warm water is provided in a reservoir at a level spaced below a layer of growing medium, whereupon the warm water is evaporated and the resultant vapour condenses at the bottom of, and is absorbed into, the layer of growing medium and thus utilised for nourishing plants growing in the medium.

The invention also includes apparatus for carrying out the new method, the apparatus comprising a heating zone for warming the water, a reservoir, a layer of growing medium spaced above the reservoir, and a waterway for leading the warm water from the heating zone into the reservoir.

The present invention advantageously uses water, such as river water, seawater, underground water or urban sewage, which may be warmed at least partly by solar radiation, although other heating means may be used, introduced into the reservoir, and then evaporated. The resultant vapour may then be condensed into water, particularly during cool nighttime, and the condensate finally utilized for the water supply for plants.

The present invention may thus stimulate afforestation and the development of agriculture in arid zones by providing water in soil of dry land.

In the accompanying drawings:-

Figure 1 is a perspective view of apparatus according to the present invention;

Figure 2 is a sectional view of a planted area;

Figure 3 is a diagram showing the effect of the

distance between the bottom of the planted soil layer and the surface of water in the reservoir;

Figure 4 is a diagram showing the effect of concentration of water retaining gel in the planted soil layer on plant growth; and,

Figure 5 is diagram showing the relationship between the solid-phase ratio of soil and effective water content.

The illustrated apparatus consists of a water warming zone A comprising a water heating pool 13, forming a warm water source, and a planting zone B for seedlings or other plants. The two zones may be connected by a waterway 14.

River water, urban sewage, underground water, seawater or the like is introduced into the water heating pool 13 and warmed by natural heat sources, such as solar radiation. Artificial heating may also be used. The system may be operated without any new construction in this respect since in many cases, water naturally heated in existing storage reservoirs or previously constructed natural ponds can be utilized as they are.

As shown in Figures 1 and 2, the planting zone B consists of a planting soil layer 1 and a evaporating water reservoir 2.

The soil layer 1 is a layer of growing medium which allows plants to grow by supporting roots of the plants and by supplying water and other nourishment. The composition of the layer varies depending on the plant to be grown. Water retaining gels 3 or the like may be mixed in the soil layer. The bottom of the layer is so lined with a water retaining sheet 4 or the like as to support the soil layer 1 and to give the layer high water retaining capability.

Furthermore, the soil layer 1 may be lined at the bottom with a water permeable porous sheet 8.

Lining with a net made of steel, stainless steel or resin polymers such as plastics is also applicable.

The water retaining gels 3 to be added in the soil layer 1 are made of water retaining resin polymers or the like which can absorb water by up to 1,000 times the weight of the polymer. The polymers to be used are, for example, of vinyl acetate-acrylic acid polymers, starch-acrylic acid graft copolymers, polyvinyl alcohol-maleic anhydride, isobutyl-maleic anhydride and polyacrylic acids.

As shown in Experiments hereinafter described, preferable mixing ratios of the water retaining gels range from 0.1% to 0.5% (w/w) and preferable solid-phase ratios of soil range from 40% to 60%.

The water retaining sheet 4 is made, for example, of nonwoven fabric with water retaining gels adhered to the surface, or of stitched up double-layered nonwoven fabrics with water retaining gels held between the layers.

The porous sheet 8 is made, for example, of hydraulic matrials such as cement, or sintered materials such as ceramics.

The reservoir 2 is constructed to support the soil later 1 by natural rocks 9 or concrete structures 10. The base 11 may be coated with asphalt 7 or the like to prevent leakage of water.

The most appropriate distance of the space between the surface of water in the reservoir 12 and the bottom of the planting soil layer 1 should be carefully determined according to various conditions such as the difference in water temperature and kinds of plants. The Experiment hereinafter described revealed that the preferable distance ranged from 10mm to 500mm.

Warm water obtained by heating water in the daytime through natural radiation, or using heating facilities, in such a place as the above mentioned

water heating pool 13 in the water heating zone A is introduced into the water reservoir 12 in the evening. The warm water therein is gradually evaporated and the resultant vapour is condensed into pure water, i.e. drops of dew, owing to the decrease in atmospheric temperature in the nighttime, on the bottom of the planting soil layer. The water migrates into and diffuses entirely through the soil layer 1 by capillary action. This daytime-nighttime diurnal cycle is repeated to provide a continued water supply to the soil.

Water circulation between the zones A and B can be accomplished by pumping which can be full-automatically controlled with such a simple facility as a thermostat operable by daytime-nighttime atmospheric temperature changes.

Alternatively, when the apparatus is constructed on a gently inclined slope, the water warming zone A may be located up the slope so that the warmed water may be naturally introduced through an intermediate gate into the water reservoir 12 of the planting zone B located down the slope. In the morning of the following day, water remaining unvapourised in the reservoir can be naturally drained further down the slope.

Furthermore, evaporation can be facilitated by blowing air in the space above the reservoir 2 to increase the condensation efficiency.

Experiment 1

This experiment was conducted to determine the effect of the distance between the surface of the water in the reservoir and the bottom of the soil layer on the growth of the plant. The result is shown in Figure 3. Relative evaluation, making the optimal value 1, is made with bent grass 56 days after planting. As a result, the most appropriate

growth was observed when the distance was set in the range between 200mm to 500mm.

When the distance was smaller than 10mm, roots of the plants tended to reach the water in the reservoir as the plant grew. The growth of the plants was accordingly inhibited. Advantageously, plant roots lengthen well enough to accelerate water absorption, since the relative humidity of the space between the surface of the water in the reservoir and planting soil is extremely high.

Further, when the distance of the space exceeded 500mm, the rate of the dew condensation tended to become slow, which resulted in poor growth of the plants.

<u>Experiment 2</u>

This experiment was conducted to estimate the effect of the concentration of water retaining gels in the soil layer on the growth of the plant. The result is shown in Figure 4. Plants used and the manner of the evaluation of the plant growth are the same as used in Experiment 1. As indicated in Figure 4, the optimal growth was obtained with the gel concentration ranging from 0.1% to 0.5% (w/w).

When the gel concentration was excessive, solidification of the gel was observed, which resulted in inhibition of elongation of plant roots.

<u>Experiment 3</u>

Figure 5 shows the effect of the solid-phase ratio, i.e. the percentage of soil and any other solids in the total mixture of solids, water and air, of the planting medium on the effective water content of the soil. Concentration of the water retaining gels used was 0.1% (w/w). As shown in Figure 5, effective water was maximally retained in the soil when the solid-phase ratio ranged from 40% to 60%, in

which the effective water content of the soil was approximately 10%.

From the foregoing description it will have been understood that the present invention provides a useful water supplying system for the plant growth in arid zones. The following effects may be anticipated.

(1).

The water suppling method according to the present invention provides precious fresh water in arid zones without necessarily using any artificial energy sources because in this method naturally available water may be heated using natural energy sources such as solar energy and in turn the condensation occurs spontaneously owing to the natural temperature difference betwen daytime and nighttime.

(2) Since various kinds of water such as seawater, river water or urban sewage near the planting area can be applicable as a water source for condensation, necessary water supply in abundance and in broad areas is always guaranteed.

(3) No complicated control devices or techniques, other than simple pumps and valves, are essential for the operation because water needed for condensation could be naturally supplied by continuously flowing water derived from natural sources. Thus, since a change of water flow is required according to the temperature difference, simple control devices such as a themostat are applicable.

Further, if the apparatus is constructed on a slope, so that the water spontaneously moves downstream, the water flow can be controlled simply by on/off switching at water gates without using any power.

(4) Concentrated salts which may accumulate in the soil during or after plant growth can be easily removed by flushing because the apparatus has an open

space under the soil layer. Subsequently, after the flushing, it is easy to alter the nutrient composition of the planting soil layer to modify or improve the soil capability.

(5) Water absorption of plants is extremely efficient because the environment of the evaporing layer, where fibre roots of the plants for water absorption reach during growth, is almost saturated with water vapour.

(6) The water supply is especially suitable for development of agriculture or afforestation in arid zones of developing countries, since, as described above, the system uses water and energy both naturally available and does not require any complicated technology or mechanics for the operation and control. The system can advantageously and effectively utilize a daytime-nighttime temperature difference as big as 20°C in these countries and water, such as natural water or drain water, which is abundant but highly salty or dirty.

CLAIMS

1. A method of watering plants, wherein warm water is provided in a reservoir at a level spaced below a layer of growing medium, whereupon the warm water is evaporated and the resultant vapour condenses at the bottom of, and is absorbed into, the layer of growing medium and thus utilised for nourishing plants growing in the medium.

2. A method according to claim 1, in which the evaporation occurs at nighttime.

3. A method according to claim 1 or claim 2, in which the water is warmed, at least partly, by solar radiation.

4. A method of watering plants, substantially as described with reference to the accompanying drawings.

5. Apparatus for carrying out the method according to any one of the preceding claims, the apparatus comprising a heating zone for warming the water, a reservoir, a layer of growing medium spaced above the reservoir, and a waterway for leading the warm water from the heating zone into the reservoir.

6. Apparatus for watering plants, substantially as described with reference to the accompanying drawings.

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